

10 DR. CICERONE: THANK YOU, DR. SPINRAD AND  
11 TO THE ORGANIZERS OF THIS CONFERENCE FOR THE IDEA OF  
12 PUTTING IT TOGETHER, IN THE FIRST PLACE, AND FOR  
13 INVITING ALL OF US TO PARTICIPATE. IT'S A REAL TREAT  
14 TO BE HERE TO SEE SO MANY PEOPLE WHOSE WORK I RESPECT  
15 SO MUCH, TO RENEW SOME OLD ACQUAINTANCES, AND TO MAKE  
16 SOME NEW ONES; AND IT'S A REAL TREAT ALSO TO HAVE  
17 LOUISE KEELING HERE AND TWO OF HER SONS COMMEMORATING  
18 THE 50TH ANNIVERSARY OF THE CO2 RECORD.

19 SEEING THE SLIDES THAT WERE JUST SHOWN  
20 BROUGHT BACK A FLOOD OF MEMORIES, NOT THE LEAST OF  
21 WHICH IS THAT WHEN MY WIFE HAD AN OFFER TO JOIN THE  
22 FACULTY AT UC, SAN DIEGO, IN THE '70S AND WE MOVED  
23 THERE, I RECEIVED A GREAT DEAL OF HELP FROM DAVE  
24 KEELING AND RAY WEISS AND ED GOLDBERG AND MIKE MULLEN  
25 AND OTHERS IN TRYING TO SET UP, BUT THERE WASN'T

0043

1 ENOUGH ROOM FOR AN OFFICE FOR ME. SO I WAS ABLE TO  
2 SHARE AN OFFICE THAT NORRIS RAKESTRAW HAD, WHO WAS  
3 HELPING DAVE KEELING. I THINK WITHOUT DAVE'S HELP, I  
4 WOULDN'T HAVE HAD THAT OFFICE. SO THAT WAS NICE TO  
5 SEE.

6 KEN, THANK YOU FOR REMINDING ME OF  
7 RAKESTRAW.

8 LET ME GO TO THE SLIDE. THIS IS AN OUTLINE  
9 OF WHAT I'M GOING TO TRY TO COVER. YOU CAN SEE THAT  
10 THIS IS A LIST OF TOPICS MOSTLY BY NOUNS. THERE'S  
11 ANOTHER WAY I COULD DESCRIBE THE MESSAGE THAT I WANT  
12 TO BRING ABOUT TODAY, IT'S KIND OF WHAT SCIENTISTS  
13 HAVE BEEN DOING, AND THEN HOW WE MOVE INTO THE FUTURE  
14 WHERE SCIENTISTS ARE GOING TO BE AS NECESSARY AS  
15 ALWAYS BUT NOT SUFFICIENT. SO, IN A WAY, WE LOOK AT  
16 THESE TOPICS AND WE SEE THAT ESPECIALLY IN THE LAST  
17 50 YEARS SCIENTISTS HAVE BEEN DETECTING CHANGES AND  
18 MEASURING AND QUANTIFYING THEM. THEY'VE BEEN  
19 REVIEWING AND ASSESSING THE QUALITY OF THE WORK AND  
20 THE MEANING. THEY'VE BEEN ATTRIBUTING THE CHANGES TO  
21 NATURAL AND HUMAN-CAUSED EVENTS. THEY'VE BEEN  
22 PREDICTING. THEY'VE BEEN COMMUNICATING.

23 THE FINAL TWO ALTERNATIVE DESCRIPTIONS HERE  
24 WOULD BE THAT: WHAT DO WE DO TO DEAL WITH WHAT'S  
25 HAPPENING? HOW DO WE LIMIT CLIMATE CHANGE AND ITS

0044

1 IMPACT?

2 SO AS I GO THROUGH, YOU CAN KEEP THOSE  
3 OTHER VERBS IN MIND.

4 IT'S, I THINK, A LOT OF FUN TO START WITH  
5 ONE OF THE EARLIEST PAPERS OF DAVE KEELING FROM 1960.  
6 THIS IS AVAILABLE THROUGH SCRIPPS' WEBSITE. THE  
7 GRAPH SHOWS SOME OF THE VERY EARLIEST CARBON  
8 DIOXIDE-IN-AIR MEASUREMENTS EXPRESSED IN THE WAY DAVE  
9 ALWAYS DID, AS A DRY AIR MOLE FRACTION, PARTS PER  
10 MILLION CARBON DIOXIDE, SHOWING THE EARLIEST  
11 MEASUREMENTS HAPPENED TO BE A VERY LOW, PROBABLY A  
12 SPRING/SUMMER MEASUREMENT, WELL BELOW 310 PARTS PER  
13 MILLION, AND THEN THE ESTABLISHED SEASONAL CYCLES  
14 WHICH HE FOUND WHICH HE DETECTED TO SOMEWHAT

15 EVERYONE'S SURPRISE, AND YOU WILL SEE THAT THE FIRST  
16 MAUNA LOA MEASUREMENTS ARE FROM EARLY 1958.  
17 WELL, AS I RECALL, THERE WAS ABOUT ONE MORE  
18 YEAR OF DATA ADDED TO THIS GRAPH WHEN ROGER REVELLE  
19 SHOWED IT TO THEN UNDERGRADUATE AL GORE AT HARVARD;  
20 AND THAT WHEN AL GORE WAS ELECTED TO THE U.S. HOUSE  
21 IN THE 1970S, HE HAD A HEARING, AND I WAS PRIVILEGED  
22 TO BE ONE OF THE WITNESSES, AND ONE OF HIS FIRST  
23 QUESTIONS WAS: WHAT HAS HAPPENED TO THOSE EARLY  
24 MEASUREMENTS THAT ROGER REVELLE SHOWED ME FROM  
25 DR. KEELING THAT WENT THROUGH ABOUT 1962?

0045

1 NOW, AL GORE KNEW THE ANSWER, BUT HE WANTED  
2 THAT RECORD TO BE UPDATED AS PART OF THOSE HOUSE  
3 HEARINGS, AND HE DID THE SAME THING THROUGHOUT THE  
4 '80S IN THE SENATE AND SO FORTH.

5 SO THIS GRAPH, EVEN BEFORE THE FAMOUS  
6 KEELING CURVE, THIS EARLY KEELING CURVE BECAME  
7 IMPORTANT IN ABOUT 1962 OR '63, WHEN ROGER REVELLE  
8 SHOWED IT TO THE STUDENT AL GORE.

9 WELL, THIS IS, OF COURSE, THE IMPORTANT  
10 GRAPH THAT MANY OF US USE SO OFTEN. THERE WAS THE  
11 STORY IN THE EARLY '90S THAT IT WAS THE ONLY  
12 SCIENTIFIC GRAPH THAT HAD EVER SEEN THE LIGHT OF DAY  
13 IN THE WHITE HOUSE.

14 (LAUGHTER).

15 IT MIGHT HAVE BEEN TRUE, I DON'T KNOW.

16 BUT THERE ARE MANY WAYS TO LOOK AT THIS  
17 GRAPH, WHICH IS OBVIOUSLY A MORE OR LESS CONTINUOUS  
18 RECORD OF CARBON DIOXIDE AT MAUNA LOA; AND ALSO IN  
19 RED FOR THE LOWER PART OF THE CURVE, THE SOUTH POLE,  
20 ANTARCTICA, THE EARLY PART OF THE CURVE, IN FACT,  
21 THIS ENTIRE CURVE IS FROM SCRIPPS' WORK, ALTHOUGH, AS  
22 YOU KNOW, THE NOAA INDEPENDENT EFFORTS HAVE BEEN  
23 EXTREMELY VALUABLE OVER THE LAST 30 YEARS OR SO.

24 THERE ARE MANY WAYS TO LOOK AT THIS GRAPH.  
25 FIRST OF ALL, THERE IS THE UNDERLYING POSITIVE TREND.

0046

1 THIS IS SUCH AN ENORMOUS INCREASE IN A GAS WHICH  
2 ISN'T ALL THAT TRACE IN THE ATMOSPHERE. THAT IS A  
3 LOT OF TONNAGE OF GAS. YOU CAN SEE THE NUMBERS AND  
4 YOU HAVE HEARD THE NUMBERS VERY OFTEN. THE ROUGH  
5 BULK OF THAT CARBON DIOXIDE INCREASE IS VERY ROUGHLY  
6 EQUAL TO THE CARBON DIOXIDE EMITTED BY BURNING OF  
7 FOSSIL FUELS OVER THE SAME TIME. AS YOU KNOW,  
8 THERE'S ABOUT A FACTOR OF TWO DIFFERENCE, AND WE WILL  
9 HEAR A LOT MORE ABOUT THAT AIRBORNE FRACTION AS THIS  
10 MEETING GOES ALONG.

11 THERE IS EVIDENCE OF HUMAN ACTIVITY; PARTLY  
12 BY THE MAGNITUDE, PARTLY BY THE TIMING, CERTAINLY THE  
13 GEOGRAPHICAL PATTERNS OF THE CARBON DIOXIDE INCREASE  
14 WHICH HAVE BEEN MEASURED IN SO MANY OTHER PLACES, AND  
15 THEN IN ISOTOPIC DATA, AND IN THE AMOUNTS IN THE  
16 OCEAN AND SO FORTH. SO THERE IS DEFINITELY EVIDENCE  
17 OF HUMAN IMPACT.

18 THERE IS ALSO THE KIND OF STORY THAT SOME  
19 OF YOU ARE JUST BEGINNING TO SPEAK ABOUT ON THE

20 PANEL, AND THAT IS THE HUMAN STORY OF THE DIFFICULTY  
21 THAT WAS INVOLVED IN ACHIEVING THIS KIND OF A RECORD,  
22 THE METICULOUS COMMITMENT TO PERFECTION, THE MERCURY  
23 MANOMETER ON THE WALL THAT COULD ONLY BE VIEWED WITH  
24 A SPYGLASS, THE VERY CAREFUL TAPING OF THE GLASS  
25 FLASKS WITH ADHESIVE TAPE IN DAVE'S GROUP. EVERYONE

0047

1 WAS SITTING AROUND ON THE FLOOR PUTTING THE ADHESIVE  
2 TAPE AROUND THE GLASS FLASKS, JUST LIKE THEY WERE  
3 PROFESSIONAL ATHLETES' ANKLES. IT WAS REALLY FUN TO  
4 WATCH. THEN, OF COURSE, NOAA'S INVOLVEMENTS. THERE  
5 ARE SO MANY STORIES INVOLVED IN THIS GRAPH. AND  
6 THEN, OF COURSE, SCIENCE THAT COMES OUT ABOUT THE  
7 EARTH'S CARBON CYCLE, SOME OF WHICH WILL BE DISCUSSED  
8 HERE LATER IN THE MEETING, ALSO.

9 HOWEVER, SOME OF THE NEW THINGS THAT  
10 HAPPENED THAT PROBABLY NO ONE EXPECTED ARE  
11 EXEMPLIFIED IN THIS GRAPH, WHICH IS THE TRACE NOW OF  
12 CARBON DIOXIDE AMOUNTS MEASURED, BUT WITH DATES ON  
13 THEM AS EARLY AS, IN THIS CASE, 450,000 YEARS AGO,  
14 SHOWING A WIGGLING TRACE OF CARBON DIOXIDE BEING --  
15 THERE'S A LITTLE POINTER HERE -- BEING LOW, LOW, LOW,  
16 AND LOW. AT FOUR TIMES IN HISTORY, YOU CAN SEE THE  
17 LOWS. THOSE ARE, ROUGHLY SPEAKING, THE ICE AGES AT  
18 20,000 YEARS AGO -- I CAN'T READ THE NUMBERS, BUT YOU  
19 CAN SEE THEM -- WHEN THE PREVIOUS ICE AGES OCCURRED.  
20 THERE IS A VERY STRONG CORRELATION BETWEEN LARGE ICE  
21 AGES AND LOW AMOUNTS OF CARBON DIOXIDE GOING BACK  
22 THROUGH THE LAST FOUR ICE AGES, AND HIGH AMOUNTS OF  
23 CARBON DIOXIDE IN THE INTERGLACIAL WARM PERIODS IN  
24 BETWEEN THE ICE AGES. BUT THE RANGE OF CARBON  
25 DIOXIDE OVER THESE HUGE SWINGS IN GEOLOGIC HISTORY,

0048

1 THAT IS, WHEN THE EARTH'S CONDITIONS CHANGED SO MUCH,  
2 THAT SWINGS ARE BETWEEN ABOUT 180 PARTS PER MILLION  
3 AND 280 PARTS PER MILLION, NEVER AS HIGH AS HAS BEEN  
4 OBSERVED IN THE KEELING AND NOAA RECORD.

5 NOW, SOME OF YOU WHO SAW AL GORE'S MOVIE  
6 SAW THIS KIND OF A GRAPH WHERE THE RIGHT-HAND SIDE,  
7 THIS RED BRANCH, PUTS ON THE GEOLOGICAL RECORD -- AND  
8 BY THE WAY, THESE MEASUREMENTS ARE OF CARBON DIOXIDE  
9 EXTRACTED FROM DATED ICE CORES, ICE CORES WHICH WERE  
10 DRILLED AND OBTAINED BY DANISH, FRENCH, SWISS, AND  
11 RUSSIAN SCIENTISTS, AND TOWARDS THE END OF THE  
12 RECORD, SOME AMERICAN SCIENTISTS IN PARTICULAR PLACES  
13 THAT WERE VERY CONTROLLED AND UNIFORM, IN GREENLAND  
14 AND IN ANTARCTICA. AND THE DATED ICE CORES COULD  
15 THEN BE EITHER CRUSHED OR MELTED, IN SOME CASES, TO  
16 EXTRACT THE CARBON DIOXIDE IN THE DATED ICE, AND  
17 THAT'S HOW THE HISTORICAL RECORD WAS CREATED THROUGH  
18 DIRECT MEASUREMENTS. BUT IF YOU THEN SUPERIMPOSE ON  
19 THIS 450,000-YEAR RECORD THE MODERN RECORD OF CARBON  
20 DIOXIDE, WHICH YOU JUST SAW IN THE PREVIOUS GRAPH, IT  
21 LOOKS LIKE THIS. AND THOSE OF YOU WHO SAW AL GORE'S  
22 MOVIE, THAT WAS ONE OF THE MOST ENTERTAINING PARTS OF  
23 THE MOVIE, THAT TO TRY TO REACH TO THE TOP OF THE  
24 GRAPH, THEY HAD TO BRING OUT A STAGE JACK AND HAVE

25 MR. GORE STAND ON THE JACK AND GO UP TO THE TOP OF  
0049

1 THE CEILING TO TOUCH IT, JUST TO EMPHASIZE  
2 DRAMATICALLY HOW RAPID AND HOW LARGE THE CO2 INCREASE  
3 HAS BEEN OUT OF THE RANGE OF THE FOUR PREVIOUS  
4 INTERGLACIAL WARM TIMES OF 280 PARTS PER MILLION UP  
5 TO ABOUT 380 NOW.

6 WELL, WHERE IS IT ALL COMING FROM? THIS IS  
7 ONE RENDITION OF A TIME HISTORY OF GLOBAL CARBON  
8 DIOXIDE EMISSIONS FROM FOSSIL FUEL BURNING, WITH A  
9 SMALL AMOUNT FROM CEMENT PRODUCTION AND, OF COURSE,  
10 JUST DIRECT GAS FLARING, NATIONAL GAS BURNING AT  
11 WELLS, SHOWING A GROWTH, A VERY, VERY, VERY RAPID  
12 GROWTH IN THE PAST 100 YEARS OF GLOBAL CARBON DIOXIDE  
13 EMISSIONS UP TO A FIGURE IN THESE UNITS OF ABOUT  
14 7 BILLION TONS OF CARBON IN THE FORM OF CARBON  
15 DIOXIDE.

16 NOW, AS YOU NOTICE, AS WE GO ALONG,  
17 SOMETIMES THESE TONNAGES ARE EXPRESSED AS CARBON  
18 DIOXIDE TOGETHER AND SOMETIMES AS CARBON. BUT THE  
19 CURRENT FIGURE IS ABOUT 7 BILLION TONS OF CARBON IN  
20 THE FORM OF CARBON DIOXIDE EMITTED ANNUALLY BY THE  
21 WORLD'S FOSSIL FUEL BURNING, A NUMBER THAT'S GROWING.  
22 AND WITH THAT KIND OF A GROWTH CURVE, ONE CAN REALIZE  
23 THAT THE FUTURE IS GOING TO BE DIFFICULT TO COPE WITH  
24 IN TERMS OF LIMITING THESE EMISSIONS.

25 YOU CAN ALSO GLEAN FROM THIS KIND OF A

0050  
1 GRAPH AN ESTIMATE OF THE TONNAGE INVOLVED, THE MASS,  
2 THE WEIGHT, THE BULK OF THE AMOUNT OF CARBON BEING  
3 RELEASED INTO THE AIR EACH YEAR, AND OF COURSE, SOME  
4 OF IT GOES INTO THE OCEAN, SO THAT PEOPLE WHO WANT TO  
5 TALK ABOUT CARBON CAPTURE AND SEQUESTRATION HAVE TO  
6 BE PREPARED FOR EXTREMELY LARGE BULK AMOUNTS.

7 WELL, ANOTHER WAY TO GET A FEELING FOR  
8 WHERE IT IS ALL COMING FROM IS TO LOOK AT SOME UNITED  
9 STATES DATA. THESE ARE UNITED STATES CARBON DIOXIDE  
10 EMISSIONS FROM ENERGY CONSUMPTION BY SOURCE; NAMELY,  
11 BURNING OF PETROLEUM, BURNING OF NATURAL GAS, BURNING  
12 OF COAL. SO YOU SEE IT IS ALMOST ALL FROM FOSSIL  
13 FUELS, WHERE NOW THE UNITS ARE BILLIONS OF TONS OF  
14 CARBON DIOXIDE TOTAL WEIGHT. SO THE U.S. MASS IS  
15 7 BILLION TONS, BUT IT IS NOW CARBON DIOXIDE, NOT  
16 JUST CARBON IN THIS GRAPH. AND YOU CAN SEE THAT  
17 HYDROELECTRICITY, FOR EXAMPLE, THE BURNING OF ANNUAL  
18 BIOMASS AT LEAST, GIVES YOU NO NET CARBON EXCHANGE  
19 AND SO FORTH. SO THAT'S BY SOURCE.

20 BY USAGE -- AND THERE ARE VERY MANY WAYS TO  
21 LOOK AT THESE DATA -- THE SAME FIGURE ADDS UP TO THE  
22 SAME AMOUNT, BUT IT IS NOW U.S. CARBON DIOXIDE  
23 EMISSIONS FROM ENERGY CONSUMPTION BY USAGE, SO  
24 LIGHT-DUTY VEHICLES -- THAT'S CARS AND TRUCKS --  
25 BURNING PETROLEUM PRODUCTS, GASOLINE, FREIGHT AND

0051  
1 SHIPPING, AIRCRAFT, ELECTRICITY GENERATION,  
2 INDUSTRIAL USAGE OF ALL KINDS, AND SO FORTH. SO IT  
3 JUST GIVES YOU A FEELING OF WHERE THE DEMAND IS.

4 LET ME NOW SWITCH TO CLIMATE, AND THERE  
5 ISN'T ENOUGH TIME TODAY TO GO INTO THE THEORY OF THE  
6 GREENHOUSE EFFECT, BUT WE HAVE A SITUATION WHERE THE  
7 DATA PRETTY WELL MATCH THE THEORY AS WELL AS WE CAN  
8 DO THE CALCULATIONS. LOOKED AT FROM A DISTANCE, OUR  
9 PLANET LOOKS KIND OF LIKE THIS CARTOON, ITS ENERGY  
10 BUDGET TO A VERY, VERY GOOD APPROXIMATION AS GIVEN BY  
11 THESE FEW NUMBERS: 342 WATTS PER SQUARE METER OF  
12 SUNLIGHT FALLING ON THE EARTH'S ATMOSPHERIC SYSTEM  
13 AVERAGED OVER DAY AND NIGHT, THE WHOLE PLANET,  
14 342 WATTS PER SQUARE METER. ABOUT 105 WATTS PER  
15 SQUARE METER IS DIRECTLY REFLECTED RIGHT BACK TO  
16 SPACE IN THE FORM OF VISIBLE LIGHT, THE WAY IT CAME  
17 IN, FROM THE TOPS OF WHITE- AND LIGHT-COLORED  
18 SURFACES, LIKE THE SHINY PARTS OF THE OCEAN AT  
19 CERTAIN ANGLES, CERTAINLY SNOW AND ICE, LIGHT-COLORED  
20 LAND. THE NET DIFFERENCE, THOUGH, 342 MINUS 105, IS  
21 237 WATTS PER SQUARE METER; AND THAT AMOUNT IS  
22 RADIATED BACK TO SPACE IN THE FORM OF PLANETARY  
23 INFRARED RADIATION. IN FACT, IF IT WEREN'T ROUGHLY  
24 BALANCED, THE PLANET WOULD EITHER BE HEATING UP OR  
25 COOLING DOWN VERY, VERY FAST; AND WE KNOW THAT IT IS

0052

1 NOT. THESE MEASUREMENTS HAVE NOW BEEN MADE WITH SOME  
2 PRECISION. AND AS CLIMATE CHANGES, THESE NUMBERS  
3 WILL STAY ABOUT THE SAME.

4 WHAT WILL NOT STAY THE SAME, THOUGH, IS THE  
5 ENERGY BALANCE IN THE LOWER LAYERS OF THE ATMOSPHERE,  
6 AND WE KNOW THAT THESE NUMBERS CAN BE CALCULATED  
7 RATHER ACCURATELY FROM LABORATORY SPECTROSCOPY DATA  
8 AND ALSO BY DOING A CALCULATION FOR WHAT SHOULD BE  
9 THE PLANET'S TEMPERATURE FOR DIFFERENT CLIMATES. I  
10 DON'T HAVE TIME TODAY, BUT IN THE ABSENCE OF A  
11 SIGNIFICANT ATMOSPHERE WITH GREENHOUSE GASSES SUCH AS  
12 ARE ILLUSTRATED HERE -- CARBON DIOXIDE, OZONE, AND  
13 WATER VAPOR, FOR EXAMPLE, IN NATURE -- IN THE ABSENCE  
14 OF THOSE GASSES AND IN THE ABSENCE OF A THICK  
15 ATMOSPHERE, ONE CAN CALCULATE THE TEMPERATURE OF THE  
16 PLANET'S SURFACE VERY ACCURATELY; BUT IN THE PRESENCE  
17 OF THOSE GASSES, WE CANNOT. WE UNDERESTIMATE THE  
18 TEMPERATURE FOR EARTH AND VENUS. THAT IS ONE KIND OF  
19 EVIDENCE OF THE GREENHOUSE EFFECT, THE REALITY IN  
20 NATURE.

21 NOW, THE PROBLEM WE HAVE, OF COURSE, IS  
22 THAT BECAUSE OF THE CARBON DIOXIDE INCREASE AND ITS  
23 PROPERTIES IN THE INFRARED, AS WELL AS OTHER  
24 GREENHOUSE GASSES SUCH AS NITROUS OXIDE BUILDING UP  
25 -- AND THIS SET OF DATA IS FROM THE AGAGE NETWORK,

0053

1 FROM THEIR WEBSITE, WHERE RAY WEISS IS THE PERSON WHO  
2 HAS DONE THE MEASUREMENTS; ALSO FROM SCRIPPS. THERE  
3 ARE OTHER SETS OF DATA, INCLUDING NOAA DATA, OF  
4 COURSE, SHOWING INCREASES IN OTHER GREENHOUSE GASSES  
5 LIKE NITROUS OXIDE, WHERE THE SOURCES OF THIS  
6 EMISSION ARE PROBABLY MORE COMPLICATED THAN CARBON  
7 DIOXIDE. IN THE CASE OF CARBON DIOXIDE, NEARLY ALL  
8 OF THE EMISSIONS FROM HUMAN ACTIVITIES IS DUE TO

9 EITHER FOSSIL FUEL BURNING OR AGRICULTURAL PURPOSES  
10 SUCH AS THE CLEARING OF FOREST LANDS FOR AGRICULTURE.  
11 IN THE CASE OF NITROUS OXIDE, IT'S CLEAR THAT THERE  
12 ARE HUMAN ACTIVITIES THAT ARE CAUSING THIS BUILD-UP,  
13 BUT IT IS NOT QUITE AS QUANTITATIVE WHICH ONE IS  
14 WHICH, IN MY OPINION.

15 WELL, ANOTHER ACHIEVEMENT OF SCIENTISTS IN  
16 QUANTIFYING AND CALCULATING AND MAKING SENSE OUT OF  
17 ALL THIS WAS THE SET OF CALCULATIONS THAT'S BEEN  
18 GOING ON NOW FOR OVER 20 YEARS TO TRY TO QUANTIFY THE  
19 STRENGTH OF THE IMPACT OF EACH OF THESE GREENHOUSE  
20 GASSES AND THE WAY THEY'RE INCREASING. SO THE HEIGHT  
21 OF THESE BAR GRAPHS REPRESENTS THE PERTURBATION TO  
22 THE ENERGY BALANCE IN THE LOWER PART OF THE  
23 ATMOSPHERE DUE TO THE INCREASE IN CO2 OVER THE LAST  
24 HUNDRED YEARS, AND THAT'S AN IMPACT OF ABOUT  
25 1.6 WATTS PER SQUARE METER. REMEMBER THAT THE ENTIRE

0054

1 IMPACT OF SUNLIGHT IS 237 WATTS PER SQUARE METER. SO  
2 ADDING UP THESE GREENHOUSE GAS IMPACTS -- AND THESE  
3 CALCULATIONS WERE FROM NOAA -- IS OVER 1 PERCENT. SO  
4 IT'S EQUIVALENT TO HAVING THE SUN BECOMING MORE THAN  
5 1 PERCENT BRIGHTER IN THE COURSE OF ABOUT  
6 1 AND A HALF HUMAN LIFETIMES, WHICH NO ONE HAS EVER  
7 SAID THAT THAT WAS PLAUSIBLE; THAT IS, THE SUN IS NOT  
8 GETTING THAT MUCH HOTTER. NO ONE HAS ANY PLAUSIBLE  
9 SUGGESTION THAT IT COULD.

10 I LOOKED BACK AT OUR FIRST CALCULATIONS ON  
11 RADIATIVE FORCING THAT BOB DICKINSON AND I DID IN  
12 1986; AND WHEN WE PROJECTED INTO THE FUTURE, WE HAD  
13 BIGGER NUMBERS FOR METHANE, AND WE HAD MUCH LARGER  
14 NUMBERS FOR CHLOROFLUOROCARBON. LATER IN THE MEETING  
15 SUSAN SOLOMON, I THINK, WILL SPEAK ON HOW THIS  
16 CHLOROFLUOROCARBON BAR WAS LIMITED THAT LEN BARRIE  
17 JUST REFERRED TO, ALSO.

18 IN THE CASE OF METHANE, WE SAW A GRAPH FROM  
19 LEN BARRIE JUST A MINUTE AGO SHOWING THAT AFTER A  
20 VERY, VERY RAPID RISE IN WORLDWIDE CONCENTRATIONS,  
21 METHANE AMOUNTS HAVE LEVELED OFF IN THE LAST 7 TO  
22 10 YEARS. WE'RE NOT SURE WHY. BUT WHEN BOB AND I  
23 DID THESE PROJECTIONS, WE THOUGHT METHANE WOULD  
24 CONTINUE TO RISE. CFC'S HAVEN'T RISEN AS MUCH. IN  
25 FACT, THERE WAS A LITTLE NOTICED PAPER PUBLISHED IN

0055

1 1990 OR '91 BY ANDY LACIS AND MICHAEL PLAVOR AND JIM  
2 HANSEN WHICH SHOWED SOMETHING EXTREMELY STUNNING: IF  
3 THE GROWTH IN THE WORLDWIDE CHLOROFLUOROCARBON  
4 INDUSTRY HAD CONTINUED AT THE RATE THAT IT HAD  
5 ACTUALLY ACHIEVED IN THE 1960S AND '70S, BY THE YEAR  
6 1990, THE RADIATIVE FORCING DUE TO THE CFC'S WOULD  
7 HAVE EXCEEDED CARBON DIOXIDE. AND THE FACT THAT THE  
8 CFC GROWTH DID NOT CONTINUE AT THAT RATE IS SOMETHING  
9 THAT WE CAN BE HAPPY ABOUT. THE MONTREAL PROTOCOL  
10 DID NOT DIRECTLY RECOGNIZE THE GREENHOUSE EFFECT OF  
11 THE CFC'S IN ITS PROVISIONS, BUT IT DID IN ITS  
12 PREAMBLE.

13 OKAY, WHAT'S BEEN HAPPENING WITH ALL OF

14 THIS EFFORT TO MEASURE AND QUANTIFY?  
15 SCIENTISTS HAVE ALSO BEEN MEASURING THINGS,  
16 AND THIS PARTICULAR GRAPH SHOWS TEMPERATURES RECORDED  
17 OVER LAND AND OCEANS OVER THE PERIOD OF THE  
18 INSTRUMENTAL RECORD BACK TO ABOUT 1880. THIS  
19 PARTICULAR GRAPH, ALTHOUGH THE CREDIT ISN'T GIVEN  
20 VERY CLEARLY, IS FROM THE NASA GISS GROUP, WHERE THE  
21 BLACK DOTS REPRESENT ANNUAL AVERAGES, THE RED LINE  
22 CONNECTS THEM WITH 5-YEAR RUNNING MEAN, AND YOU SEE  
23 -- WELL, ZERO ON THIS GRAPH DOES NOT MEAN ZERO  
24 DEGREES ON ANY SCALE; IT'S A REFERENCE TEMPERATURE IN  
25 THIS CASE BY THE AVERAGE OF THE OBSERVATIONS BETWEEN

0056

1 1951 AND 1980, SO ZERO MEANS THE AVERAGE OF 1951 TO  
2 '80. PRIOR TO THAT THERE WAS A SIGNIFICANT RUN-UP IN  
3 TEMPERATURE FROM ABOUT 1900 TO ABOUT 1940, AND THEN A  
4 DECREASE FROM ABOUT 1940 TO 1975, AND THEN A SHARP  
5 MONOTONIC INCREASE SINCE THE LATE '70S TO CURRENT.  
6 SO THAT THIS LAST 30-YEAR PERIOD IS SPECIAL IN  
7 SEVERAL RESPECTS: IT'S THE FASTEST, MOST CONTINUOUS  
8 INCREASE IN TEMPERATURE. THIS IS NOW A GLOBAL  
9 AVERAGE WITH URBAN HEAT ISLAND EFFECTS REMOVED. SO  
10 IT'S AN UNPERTURBED GLOBAL AVERAGE. THE RATE OF THE  
11 INCREASE AND THE SIZE OF THE INCREASE IS  
12 UNPRECEDENTED, AND IT ALSO EXCEEDS THE VARIABILITY  
13 THAT ANYONE HAS BEEN ABLE TO REPRODUCE IN A FIRST  
14 PRINCIPLE'S MODEL OF TEMPERATURE.

15 THE TEMPERATURE INCREASE IS NOT UNIFORM.  
16 MANY OF YOU KNOW THESE DATA; THAT ON A  
17 TWO-DIMENSIONAL PLOT, YOU CAN SEE AREAS OF FALSE  
18 COLOR IMAGING SHOWING VERY HIGH WARMINGS OBSERVED  
19 OVER THIS 50-YEAR PERIOD, 1955 TO 2005, IN THE HIGH  
20 LATITUDE REGIONS OF THE ARCTIC AND SUBARCTIC REGIONS  
21 AND DOWN NEAR THE ANTARCTIC PENINSULA; AREAS OVER  
22 OCEAN, RELATIVELY SMALL WARMING; THE CONTINENTS,  
23 INTERMEDIATE IN THE TEMPERATE ZONE. THERE IS NOW NO  
24 PLACE WHERE TEMPERATURES ARE BEING MEASURED OF ANY  
25 GEOGRAPHICAL SIZE TO SPEAK OF WHERE THE TEMPERATURES

0057

1 ARE NOT INCREASING. THIS IS ANOTHER KIND OF EVIDENCE  
2 THAT THE TEMPERATURE ANOMALY OF THE LAST 30 TO  
3 40 YEARS IS NOT NATURAL; THAT IT IS BEING CAUSED BY  
4 HUMAN INFLUENCE IN THIS CASE.

5 ANOTHER KIND OF DATA THAT, OF COURSE, IS  
6 EXCEEDINGLY IMPORTANT ARE SEA LEVEL RISE. THIS IS A  
7 RECORD OF ABOUT 120 YEARS DATA, 110 YEARS DATA FROM  
8 TRADITIONAL TIDE GAUGES AND RECORDS FROM ALL OVER THE  
9 WORLD. SOME OF YOU KNOW THAT THE SEA LEVEL RISE HAS  
10 NOT BEEN UNIFORM IN THE DIFFERENT OCEAN BASINS; BUT  
11 WHEN YOU DO A GLOBAL AVERAGE, THE RISE IS ABOUT  
12 15 CENTIMETERS PER CENTURY, WHICH IS 1 AND A HALF  
13 MILLIMETERS PER YEAR.

14 YOU NOTICE THAT THERE IS A RED PART OF THIS  
15 GRAPH, THE LAST DOZEN OR 15 YEARS, THIS IS NOW THAT  
16 RECORD SHOWN FROM ABOUT 1992 THROUGH 2005 OR SO, OF  
17 VARIOUS PHYSICAL OCEANOGRAPHY-TYPE REMOTE SENSING,  
18 TOPEX AND JASON EXPERIMENTS, SHOWING SEA LEVEL RISE

19 MEASURED MUCH MORE GLOBALLY, WITH VERY, VERY PRECISE  
20 INSTRUMENTS, SHOWING A RATE OF SEA LEVEL RISE OF  
21 ABOUT DOUBLE OF WHICH HAD BEEN INFERRED FROM THE TIDE  
22 GAUGE, SO THAT THIS RATE OF SEA LEVEL RISE, WHILE IT  
23 CONNECTS WITH THE PREVIOUS RECORD AS WELL AS YOU CAN  
24 EYEBALL IT, THIS RECORD IS MORE PRECISE, IT IS MORE  
25 GEOGRAPHICALLY REPRESENTATIVE, AND IT'S TWICE AS

0058

1 FAST. NOW, AT THIS POINT NO ONE THAT I KNOW OF IS  
2 SPEAKING WITH ANY AUTHORITY THAT THIS IS ACTUALLY AN  
3 INCREASE IN THE RATE OF SEA LEVEL RISE OR WHETHER  
4 IT'S JUST A MORE PRECISE MEASUREMENT OVER A SHORTER  
5 PERIOD OF TIME, BUT IT DOES CAUSE SOME WORRY THAT THE  
6 INFERRED RATE OF SEA LEVEL RISE IS NOW DOUBLE WHAT IT  
7 WAS 15 YEARS AGO.

8 NOW, MANY OF YOU HAVE SEEN GRAPHS OR IMAGES  
9 LIKE THIS, LOOKING DOWN ON GREENLAND, AND SAY, WELL,  
10 IT SURE LOOKS LIKE THE EXTENT OF SNOW AND ICE OVER  
11 GREENLAND HAS DECREASED; AND YES, IT DOES. WHAT I  
12 WANT TO DO NOW IS TO SHOW JUST, AS AN EXAMPLE,  
13 THOUGH, OF HOW BEAUTIFULLY THIS KIND OF SCIENCE IS  
14 BEING DONE NOW WITH REALLY HIGH-TECH INSTRUMENTS.

15 THIS IS A CARTOON OF ONE OF THE SATELLITE  
16 MEASUREMENTS THAT'S UP NOW, THE GRACE EXPERIMENT THAT  
17 WAS LED OUT OF THE UNIVERSITY OF TEXAS. IT RELIES ON  
18 THE USE OF PART OF THE CONSTELLATION OF GPS GLOBAL  
19 POSITIONING SYSTEM SATELLITES, AND THEN THE TWO  
20 ACTIVE SATELLITES ARE THESE TWO LITTLE ONES IN THE  
21 RIGHT-HAND PORTION OF THE GRAPH, WHICH ARE THE  
22 GRAVITY EXPERIMENT, THE GRACE MISSION SATELLITES. SO  
23 THE POSITIONS OF ALL OF THESE SATELLITES ARE MEASURED  
24 BY THE GPS SATELLITES, BUT THE RELATIVE POSITIONS OF  
25 THE TWO GRACE SATELLITES ARE TRACKED BY K-BAND

0059

1 LINKAGE, MICROWAVE LINKAGE, BETWEEN THEM SO THAT AS  
2 THESE SATELLITES GO AROUND THE WORLD AND THEY GO OVER  
3 WHAT IS LABELED HERE A GRAVITATIONAL ANOMALY, AS THEY  
4 MOVE OVER, THE LEADING SATELLITE BEGINS TO FEEL A  
5 SMALL PERTURBATION OF THE UNDERLYING MASS BULGE, IN  
6 THIS CASE ICE BENEATH GREENLAND, BEFORE THE TRAILING  
7 SATELLITE DOES. AND AS THEY PASS OVER, BY KEEPING  
8 EXTREMELY GOOD RECORD OF EACH OTHER'S RELATIVE  
9 POSITION -- AND NOTICE IT SOMEWHAT WOBBLER IN THAT  
10 DISTANCE -- ONE CAN INFER AFTER A PERIOD OF TIME HOW  
11 BIG WAS THE GRAVITATIONAL ANOMALY BENEATH THE  
12 SATELLITES. AND OVER A PERIOD OF A FEW YEARS NOW,  
13 THESE SCIENTISTS HAVE QUANTIFIED THE ICE LOSS OVER  
14 GREENLAND, AND ANTARCTICA FOR THAT MATTER, SO THAT  
15 THE BAD NEWS IS IT IS ONLY A FEW-YEAR RECORD, BUT THE  
16 GOOD NEWS FROM A SCIENTIFIC POINT OF VIEW THAT THE  
17 DEDUCED RATE OF ICE MASS LOSS BY THIS GRAVITATIONAL  
18 ANOMALY EXPERIMENT AGREES VERY, VERY WELL WITH THE  
19 ICE MASS LOSS WHICH IS DEDUCED FROM ANOTHER HIGH-TECH  
20 INSTRUMENT, ORBITING SATELLITES WITH SYNTHETIC  
21 APERTURE RADAR, WHICH IS INTERFEROMETRY, TO MEASURE  
22 THE HEIGHT CHANGES OVER GREENLAND AND ANTARCTICA. SO  
23 IF YOU SEE THE HEIGHT GOING DOWN, YOU CAN INFER AN



24 ICE MASS LOSS AND THEN FURTHER COMPARE THAT WITH  
25 WHAT'S BEING DEDUCED FROM THE GRAVITATIONAL

0060

1 MEASUREMENT, AND YOU GET ABOUT THE SAME ANSWER TO  
2 WITHIN EXPERIMENTAL ERROR AT THIS POINT. SO, AS I  
3 SAY, THIS SCIENCE IS NOT BEING DONE IN A WAY THAT OUR  
4 GRANDFATHERS WOULD HAVE DONE IT, AND GRANDMOTHERS; IT  
5 IS BEING DONE MUCH, MUCH MORE PRECISELY WITH  
6 HIGH-TECH EXPERIMENTS.

7 AS I SAID EARLIER, THIS TEMPERATURE RECORD  
8 FROM GISS IN THIS CASE SHOWS SOMETHING SPECIAL WITHIN  
9 THE LAST 30 YEARS, WHICH WE HAVE NOW ATTRIBUTED, AND  
10 AS THE QUOTES FROM THE IPCC SEA REPORT SAY, MOSTLY  
11 IT'S VERY LIKELY DUE TO HUMAN ACTIVITIES.

12 THERE IS SOMETHING ELSE SPECIAL ABOUT THIS  
13 PAST 30-YEAR PERIOD; NAMELY, IT'S THE FIRST TIME IN  
14 HUMAN HISTORY THAT WE HAVE MEASURED THE OUTPUT OF THE  
15 SUN WITH ENOUGH PRECISION AND CONTINUITY TO BE ABLE  
16 TO SAY WHETHER THE SUN ITSELF CAUSED THIS WARMING.  
17 NOW, UP UNTIL JUST ABOUT A FEW YEARS AGO, MAYBE SIX  
18 OR EIGHT YEARS AGO, IT WAS TENABLE TO SAY THAT WE  
19 THINK THE SUN MAY HAVE CAUSED SOME OF THIS OR ALL OR  
20 MOST OF THE WARMING, AT LEAST SOME OF IT. IT ISN'T  
21 ANYMORE. THIS GRAPH IS FROM JUDITH LEAN AND CLAU  
22 FROHLICH, WHERE THEY HAVE STRUNG TOGETHER SOME TOTAL  
23 SOLAR IRRADIANCE DATA, THAT IS THE SUNLIGHT REACHING  
24 THE EARTH AS THE SATELLITE ORBITS, AND THEY HAVE  
25 RECORDED ITS VARIATIONS. THEY HAVE CORRECTED THE

0061

1 DATA FOR WHAT IS CLEARLY DISCONTINUITY IN ONE  
2 INSTRUMENT, AND THIS IS THE RECORD THAT THEY GET.  
3 THE SUNLIGHT, FOR THOSE OF YOU ARE GOOD AT ARITHMETIC  
4 WILL KNOW THAT 342 MULTIPLIED BY THE GEOMETRICAL  
5 FACTOR OF 4 IS EXACTLY 1368. IT IS OFF BY ABOUT  
6 1 WATT PER SQUARE METER. BUT THE POINT IS THE  
7 VARIATION IS ROUGHLY THAT OF A 11-YEAR SUN-SPOT  
8 CYCLE. THE PEAK-TO-PEAK AMPLITUDE IS 0.1 PERCENT.  
9 NOW, I'VE ALREADY TOLD YOU THAT THE GREENHOUSE EFFECT  
10 DUE TO THE HUMAN-CAUSED GREENHOUSE GAS CONCENTRATION  
11 IS MORE THAN 1 PERCENT. SO THE HUMAN-CAUSED  
12 GREENHOUSE EFFECT IS AT LEAST 10 TIMES LARGER, IT'S  
13 SUSTAINED, AND IT'S GROWING COMPARED TO THIS VERY,  
14 VERY SMALL SOLAR OSCILLATION, WHICH HAS NOW BEEN  
15 MEASURED. SO IT IS UNTENABLE NOW TO SAY THAT SUN  
16 VARIATIONS ARE CAUSING THIS MOST RECENT WARMING.

17 WELL, WHERE DO WE GO FROM HERE?

18 I SAID THAT SCIENTISTS ARE ASSESSING,  
19 PREDICTING. THIS IS WHAT'S REGARDED AS A FAIRLY  
20 CONSERVATIVE PROJECTION AHEAD OF WHAT WORLD ENERGY  
21 CONSUMPTION WILL BE STRUNG ONTO A RECORD FROM 1970 TO  
22 2005 OF WHAT IT HAS ACTUALLY BEEN; AND YOU'LL SEE  
23 THAT -- JUST TO GIVE US SOME ORIENTATION HERE, THE  
24 UNITS ARE QUADRILLION BTU'S, WHICH DON'T MATTER TOO  
25 MUCH. BUT IN THE EARLY 1970S, THE WORLD WAS

0062

1 CONSUMING 207 QUADRILLION BTU'S PER YEAR; IN THE YEAR  
2 2005, IT WAS EXACTLY DOUBLE, 414; 412. OKAY, SO

3 DOUBLING IN 35 YEARS, THAT IS A 2-PERCENT-PER-YEAR  
4 GROWTH RATE. THAT SHOULDN'T CONFUSE ANYBODY. THAT'S  
5 EXACTLY WHAT HAS HAPPENED.

6 PROJECTING AHEAD TO THE FUTURE, WE SEE  
7 ANOTHER 50-PERCENT INCREASE IN ENERGY CONSUMPTION IN  
8 THE NEXT 20 YEARS OR SO, PERHAPS 25, BUT YOU WILL SEE  
9 A DIFFERENCE; THAT THE ENERGY CONSUMPTION IN THE  
10 LATTER PART OF THE 20TH CENTURY WAS DOMINATED BY  
11 MATURE MARKETS: THE UNITED STATES, CANADA, JAPAN,  
12 WESTERN EUROPE. IN THE FUTURE, MOST OF THIS GROWTH  
13 IS DUE TO DEVELOPING AND EMERGING ECONOMIES, AND YOU  
14 KNOW WHERE THEY ARE. THAT'S HOW THEY'RE GROWING.

15 WELL, WHERE IS IT HEADING? I WILL SHOW  
16 JUST ONE INDICATION. THE ONLY REASON I DON'T LIKE TO  
17 SHOW THIS NEXT GRAPH, IT CONTINUES TO USE GLOBAL  
18 AVERAGE SURFACE TEMPERATURE, WHICH IN TERMS OF  
19 EXPLAINING TO PEOPLE WHAT THE CONCERN IS, IT IS NOT  
20 VERY GOOD. BUT I WILL JUST FOCUS ON ONE OF THESE  
21 GRAPHS.

22 THIS IS FROM A UK GROUP PUBLISHED IN THE  
23 YEAR 2000 OF A MODEL, MATHEMATICAL MODEL, A FLUID  
24 DYNAMICAL MODEL OF THE EARTH'S ATMOSPHERE AND OCEAN,  
25 TAKING INTO ACCOUNT ALL FORCINGS. THIS IS THE

0063

1 TEMPERATURE RECORD WHICH THE MODELS COULD GENERATE,  
2 FAIRLY GOOD AGREEMENT, VERY GOOD AGREEMENT WITH WHAT  
3 WAS ACTUALLY OBSERVED OVER THE LAST 30 YEARS. AND  
4 PROJECTING INTO THE FUTURE WITH THAT KIND OF A FOSSIL  
5 FUEL SCENARIO, WITH ANY REASONABLE FOSSIL FUEL  
6 SCENARIO, ONE EXPECTS A MUCH LARGER WARMING IN THE  
7 REST OF THE CENTURY, OF COURSE. NOW, AS YOU KNOW,  
8 THERE ARE MANY MORE IMPORTANT FACTORS IN CLIMATE,  
9 SUCH AS PRECIPITATION, EXTREME EVENTS, AND SO FORTH,  
10 SO THE GLOBAL AVERAGE TEMPERATURE IS JUST THE EASIEST  
11 TO PREDICT. UNFORTUNATELY, IT IS NOT THE EASIEST TO  
12 IDENTIFY WITH.

13 WELL, WHERE DO WE GO FROM HERE? WHAT DO WE  
14 DO? A LOT OF THIS CONFERENCE IS FOCUSED ON HOW WE  
15 DEAL WITH THIS CHANGING CLIMATE; AND WE USE WORDS  
16 LIKE "MITIGATION" AND "ADAPTATION," OF COURSE.

17 FIRST OF ALL, I WILL SHOW THIS. THIS IS AN  
18 UNREADABLE CHART, AND THAT'S PART OF MY MESSAGE.

19 (LAUGHTER)

20 IT WAS GIVEN TO ME BY RESOURCES FOR THE  
21 FUTURE JUST A COUPLE OF WEEKS AGO. IT IS A LIST OF  
22 MARKET-BASED CLIMATE CHANGE LEGISLATION INTRODUCED IN  
23 THE CURRENT UNITED STATES CONGRESS. SO AS YOU CAN  
24 SEE, WITH ALL OF THOSE ADJECTIVES, THIS IS A LIMITED  
25 LIST. THESE ARE ONLY THE MARKET-BASED LEGISLATION

0064

1 INTRODUCED, WITH CATEGORIES GOING ACROSS: WHO IS  
2 REGULATED, WHAT ARE THEIR ALLOWANCE OR ALLOCATIONS,  
3 PRICE, STABILITY, OFFSET, TECHNOLOGY,  
4 COMPETITIVENESS, AND SO FORTH, WITH A LIST OF WHO IS  
5 SPONSORING THEM. SO THE MESSAGE HERE IS THAT TO DEAL  
6 WITH CLIMATE CHANGE, WHILE WE'RE GOING TO NEED  
7 PRIVATE PARTIES, BUSINESS LEADERSHIP, AND GOVERNMENT

8 INVOLVEMENT, IT'S NOT CLEAR AT ALL HOW WE'RE GOING TO  
9 DEAL WITH THESE THINGS. AND CONGRESS IS TRYING VERY  
10 HARD; BUT AS YOU KNOW, NONE OF THESE BILLS HAVE BEEN  
11 PASSED. VERY FEW BILLS HAVE BEEN PASSED THIS YEAR OF  
12 ANY KIND.

13 THIS IS A SOMEWHAT EASIER CHART TO READ IN  
14 THE SENSE THAT IT IS MORE LEGIBLE, BUT ALSO IT  
15 FOCUSES ON CARBON DIOXIDE EMISSIONS AND GIVES A  
16 COMPARISON OF THE IMPACTS OF VARIOUS PIECES OF  
17 LEGISLATION THAT HAVE BEEN INTRODUCED ON A HISTORICAL  
18 RECORD OF CARBON DIOXIDE EMISSIONS, AND A REASONABLE  
19 PROJECTION FORWARD, AS WELL AS THOSE FROM  
20 ELECTRICITY.

21 SO MY POINT HERE IS TO SAY THAT ALL THROUGH  
22 CONGRESS, THERE ARE MANY EFFORTS UNDERWAY TO TRY TO  
23 DEAL WITH CLIMATE CHANGE, FOCUSING MOSTLY ON CARBON  
24 DIOXIDE AND ENERGY. HOWEVER, MANY OF YOU KNOW THAT  
25 THAT IS NOT THE ONLY THING THAT WE HAVE TO FOCUS ON.

0065

1 WELL, LET'S LOOK AT THE PICTURE FROM A BIT  
2 BIGGER DISTANCE, NOT JUST CONGRESS, BECAUSE AS I SAID  
3 BEFORE, THIS CHALLENGE OF DEALING WITH CLIMATE CHANGE  
4 IS NOT JUST FOR SCIENTISTS ANYMORE. SCIENTISTS WILL  
5 BE NECESSARY BUT NOT SUFFICIENT. BUSINESS  
6 LEADERSHIP, NGO'S, WHAT PRIVATE PARTIES DO, AND WHAT  
7 GOVERNMENTS DO ARE GOING TO BE VERY IMPORTANT. SO  
8 WHILE SCIENTISTS WILL CONTINUE TO DETECT AND MEASURE  
9 AND QUANTIFY AND ASSESS AND PREDICT AND COMMUNICATE,  
10 WE ALSO HAVE TO DEAL WITH THE ISSUES. AND WE HAVE  
11 TWO BASIC VERBS THAT HAVE CREPT INTO OUR VOCABULARY:  
12 "MITIGATE" AND "ADAPT." SO ONE DEFINITION OF  
13 "MITIGATION" IS TO REDUCE THE AMOUNT OF CLIMATE  
14 CHANGE OR TO SLOW IT; AND "ADAPTATION" IS TO REDUCE  
15 THE IMPACTS.

16 WELL, WE HAVE MANY EXAMPLES, AND SOME, I  
17 THINK, EXCELLENT PRESENTATIONS COMING UP ON DIFFERENT  
18 STRATEGIES AND TECHNIQUES FOR MITIGATION AND  
19 ADAPTATION. THE MITIGATION OPTIONS ARE BASICALLY  
20 EVERYTHING WE DO THAT INVOLVES ENERGY AND  
21 AGRICULTURE, AS WELL AS A LOT OF OTHER INDUSTRIAL  
22 PROCESSES. SOFT MITIGATION WOULD BE TARGETS SUCH AS  
23 ENERGY EFFICIENCY. WE HAVE SO MUCH TO GAIN BY ENERGY  
24 EFFICIENCY THAT YOU WOULD THINK THAT THERE'S  
25 MOTIVATION THAT EACH ONE OF US CAN IDENTIFY WITH.

0066

1 ALL KINDS OF BENEFITS OF ENERGY EFFICIENCY, ALL THE  
2 WAY THROUGH TO OPTIONS WHICH ARE MUCH, MUCH LESS  
3 POPULAR, MUCH, MUCH LESS THOUGHT-OUT, AND MUCH, MUCH  
4 MORE HARD, I WOULD SAY -- "HARD" IN THE SENSE OF NOT  
5 MALLEABLE, THE GEOENGINEERING, FOR EXAMPLE. AND WE  
6 WILL HAVE SOME DISCUSSION, I THINK FRIDAY MORNING,  
7 ROB SOCOLOW TOLD ME, ON GEOENGINEERING.

8 WELL, WHERE DO WE GO ON MITIGATION AND  
9 ADAPTATION? THERE ARE MANY, MANY KINDS OF BUSINESS  
10 LEADERSHIP EMERGING AND MARKETS DEVELOPING, BUT I  
11 WANTED TO MENTION, AGAIN, WHAT CONGRESS IS DOING.  
12 THERE'S TWO PARTICULARLY VERY SENIOR CONGRESSMAN,

13 DICKS FROM WASHINGTON AND OBEY FROM WISCONSIN, WHO  
14 HAVE INTRODUCED A BILL WHICH IS PENDING APPROVAL --  
15 THEY BOTH HAVE A GREAT DEAL OF INFLUENCE -- WHICH  
16 WILL CREATE A NEW COMMISSION IN THE UNITED STATES TO  
17 CREATE AND ALLOCATE A RESEARCH FUND IN THE FEDERAL  
18 GOVERNMENT ABOUT MITIGATION AND ADAPTATION, AND ONE  
19 OF THE REASONS WE'RE PAYING ATTENTION TO IT IS IT  
20 NAMES ME TO CHAIR THE COMMISSION.

21 (LAUGHTER)

22 WE DIDN'T ASK FOR THIS, BUT I THINK IT IS A  
23 GOOD IDEA.

24 THE COMMISSION WILL BE COMPRISED OF THE  
25 ADMINISTRATOR OF EPA, THE DIRECTOR OF THE NATIONAL

0067

1 SCIENCE FOUNDATION, THE ADMINISTRATOR OF NASA, THE  
2 DIRECTOR OF THE USGS, THE UNDERSECRETARY FOR SCIENCE  
3 OF THE DEPARTMENT OF ENERGY, THE ADMINISTRATOR --  
4 THAT IS, CONRAD LAUTENBACKER -- OF NOAA, AND A FEW  
5 OTHERS; AND I'M SUPPOSED TO CHAIR THE COMMISSION.  
6 AND WHAT WE'RE SUPPOSED TO DO IS TO MAP OUT A WAY TO  
7 SPEND A \$50 MILLION ANNUAL FUND, WHICH THESE AGENCIES  
8 WILL ADMINISTER, WHICH WILL DO RESEARCH ON MITIGATION  
9 AND ADAPTATION, TO TRY TO FIGURE OUT WHAT IS A GOOD  
10 IDEA AND WHAT'S FEASIBLE OR NOT.

11 SO IN THE WORLD AT LARGE WHAT WE SEE IS  
12 CITIES AND STATES ARE ACTUALLY DOING THINGS IN  
13 REGIONS, AND THE FEDERAL GOVERNMENT IS TRYING TO DEAL  
14 WITH THE SITUATION BUT HASN'T YET COME UP WITH ITS  
15 APPROACH, AND THERE ARE MANY, MANY OTHER PIECES OF  
16 LEGISLATION WHICH ARE PENDING NOW BY VERY INFLUENTIAL  
17 CONGRESSMEN AND WOMEN IN ADDITION TO THE DICKS AND  
18 OBEY LEGISLATION; AND MANY OF THEM FOCUS ON  
19 MITIGATION AND ADAPTATION. THERE IS A MOOD IN  
20 CONGRESS THAT SAYS, LOOK, WE'RE CONVINCED, WE SEE  
21 THINGS HAPPENING, WE THINK IT'S PROBABLY DUE TO  
22 HUMANS, BUT WE WANT TO DO SOMETHING ABOUT IT AND NOT  
23 JUST THE SCIENCE RESEARCH ANYMORE.

24 WELL, ON AN INTERNATIONAL LEVEL, LET'S ALSO  
25 REMIND OURSELVES WE HAVE A GLOBAL SITUATION AT HAND

0068

1 WITH THE EMERGING MARKET ECONOMIES GROWING MUCH  
2 FASTER THAN THE REST OF US, AND THEIR FUTURE ENERGY  
3 DEMAND IS GROWING MUCH FASTER THAN OURS WILL. SO  
4 WHAT DO WE HAVE INTERNATIONALLY?

5 IN 1992, THE UN, UNITED NATIONS, FRAMEWORK  
6 CONVENTION ON CLIMATE CHANGE WAS AGREED TO IN  
7 RIO DEJANEIRO, AND IT WAS SIGNED BY PRESIDENT BUSH,  
8 THE FIRST PRESIDENT BUSH, ALONG WITH ABOUT 150 OTHER  
9 NATIONS, AND ARTICLE 2 STATES THE OBJECTIVE, TO WHICH  
10 PEOPLE AGREE, AND I HAVE HIGHLIGHTED IN YELLOW,  
11 LANGUAGE HERE THAT ONE OF THE GOALS IS TO STABILIZE  
12 GREENHOUSE GAS CONCENTRATIONS IN THE ATMOSPHERE AT A  
13 LEVEL THAT WOULD PREVENT DANGEROUS ANTHROPOGENIC  
14 INTERFERENCE WITH THE CLIMATE SYSTEM. AND ONE OF THE  
15 REASONS WHY WE DO NOT HAVE A SUCCESSFUL COMPREHENSIVE  
16 INTERNATIONAL AGREEMENT YET IS THAT PEOPLE HAVEN'T  
17 AGREED ON WHAT "DANGEROUS" MEANS.

18                   IN 2001 INEZ FUNG AND I WERE ON A COMMITTEE  
19 TOGETHER, REQUESTED BY THE WHITE HOUSE, THIS  
20 PRESIDENT BUSH, AND I DON'T KNOW IF INEZ CAUGHT ON,  
21 BUT I DIDN'T CATCH ON UNTIL MUCH LATER THAT THE  
22 YELLOW QUESTION THAT IS HIGHLIGHTED HERE OUT OF A  
23 LIST OF 14 QUESTIONS, THE YELLOW QUESTION WAS THE  
24 LOADED ONE. THE QUESTION WAS: "HAS SCIENCE  
25 DETERMINED WHETHER THERE IS A 'SAFE' LEVEL OF

0069

1 CONCENTRATION OF GREENHOUSE GASSES?"

2                   AND LIKE GOOD SCIENTISTS, WE SAID A  
3 LONG-WINDED ANSWER: ON THE ONE HAND, THIS; ON THE  
4 OTHER HAND, THIS. IF YOU'RE IN A RICH COUNTRY AND  
5 YOU CAN ANTICIPATE CLIMATE CHANGE, YOU CAN DEAL WITH  
6 IT THROUGH TECHNOLOGY, AND YOU HAVE CAPITAL AND AN  
7 EDUCATED POPULATION, A CERTAIN LEVEL OF CLIMATE  
8 CHANGE MIGHT NOT BE SO DANGEROUS. IF YOU'RE IN A  
9 POOR COUNTRY, WITHOUT AVAILABLE TECHNOLOGY, WITHOUT  
10 CAPITAL TO INVEST, WITHOUT AN EDUCATED POPULATION,  
11 AND VERY LITTLE ABILITY TO ANTICIPATE THE CHANGE AND  
12 TO RESTRUCTURE YOUR INDUSTRIES AND AGRICULTURE, YOU  
13 MIGHT BE IN DANGER EARLIER.

14                   WELL, APPARENTLY, THAT WASN'T ENOUGH TO  
15 ANSWER THE QUESTION. BUT THERE'S ANOTHER PART OF  
16 THIS QUESTION WHICH IS LOADED. IT SAYS, "HAS SCIENCE  
17 DETERMINED WHETHER THERE IS A 'SAFE' LEVEL?" AND HOW  
18 DO WE DO THAT?

19                   WELL, THERE HASN'T BEEN VERY MUCH WORK DONE  
20 ON DETERMINING WHAT IS DANGEROUS AND WHAT IS NOT.  
21 I'M CERTAINLY NOT AWARE OF ALL OF IT, BUT I'M AWARE  
22 OF SOME OF THIS WORK, AND THERE ISN'T MUCH. THERE  
23 ARE ONLY A FEW SCIENTISTS THAT ARE TRYING TO COME UP  
24 WITH A SCIENTIFICALLY-BASED DEFINITION, AND THEY'RE  
25 FOCUSING ON THINGS LIKE IRREVERSIBLE CHANGES. FOR

0070

1 EXAMPLE, A SEA LEVEL CHANGE COULD WELL BE  
2 IRREVERSIBLE IN ANY REASONABLE TIME SPAN. LOSS OF  
3 BIODIVERSITY IS THOUGHT TO BE IRREVERSIBLE.

4                   THERE IS A GREAT QUOTE FROM THE FAMOUS  
5 ECOLOGIST ALDO LEOPOLD FROM ABOUT 1948, WHICH I  
6 REALLY LOVE. HE SAID, "THE FIRST RULE FOR SUCCESSFUL  
7 TINKERING IS TO SAVE ALL OF THE PARTS."

8                   (LAUGHTER)

9                   AND I THINK THAT HAS TO APPLY TO THE  
10 BIOLOGICAL WORLD. SO THAT MIGHT BE INVOLVED.

11                   AND THEN, OF COURSE, THE RATE OF  
12 DISRUPTION; IF IT'S GREATER THAN THE RATE AT WHICH WE  
13 CAN ADAPT MIGHT ALSO BE REGARDED AS DANGEROUS.

14                   BUT I WANT TO CLOSE ON THIS FINAL QUESTION:  
15 WHO SHOULD DEFINE "DANGEROUS"?

16                   THE QUESTION FROM THE WHITE HOUSE SAID:  
17 HAS SCIENCE DEFINED A DANGEROUS LEVEL OR A SAFE  
18 LEVEL?

19                   I'M NOT SO SURE THAT THIS IS A QUESTION  
20 JUST FOR SCIENTISTS. IN A REPRESENTATIVE DEMOCRACY,  
21 WE, I THINK, HAVE TO EXPECT OUR ELECTED LEADERS TO  
22 PARTICIPATE IN THIS DEFINITION; HOWEVER, I THINK

23 THEY, IN TURN, ARE GOING TO SAY THAT SCIENTISTS HAVE  
24 TO PROVIDE A BASIS. SO WE HAVE A GREAT CHALLENGE IN  
25 FRONT OF US.

0071

1           LOOKING BACK ON THIS LAST 40 OR 50 YEARS,  
2 JUST LOOKING BACK 10 YEARS AGO TO WHEN THE MAUNA LOA  
3 OBSERVATORY HAD ITS 40TH ANNIVERSARY CELEBRATION,  
4 WHICH I ATTENDED AND REALLY ENJOYED, IT'S BEEN A VERY  
5 STRIKING DECADE, I THINK THE PACE OF WHAT WE HAVE TO  
6 DO, WHAT'S REQUIRED OF US AND OUR ROLE IN SOCIETY AS  
7 SCIENTISTS AND THE NECESSITY FOR US TO COLLABORATE  
8 WITH THE ENLIGHTENED BUSINESS COMMUNITY AND WITH  
9 GOVERNMENT LEADERS ALL AROUND THE WORLD IS GOING TO  
10 BE REALLY STUNNING IN ITS DRAMA IN THE NEXT DECADE OR  
11 TWO. SO I'M VERY HAPPY TO SEE SO MANY YOUNG PEOPLE  
12 HERE AT THE TABLE BECAUSE THE NEXT TEN YEARS IS  
13 REALLY GOING TO BE EXCITING AND EXTREMELY IMPORTANT  
14 FOR US ALL TO DO GOOD WORK AND TO BE ABLE TO  
15 COMMUNICATE.

16           SO I WILL STOP THERE AND THANK YOU AGAIN,  
17 RICK.